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ABSTRACT

Subject matter concept attainment by adult Ss was studied by experimentally manipulating instructional instances which were either positive or negative, clear or obscure, or presented in large or small variety. Training and testing instances were composed of case studies communicated via prose description that had been analyzed for relevant and irrelevant attributes. Conceptualization was defined as generalization within and discrimination between classes and was assessed by having 176 undergraduate volunteers classify new positive and negative case studies after instruction from a definition and selected instances. Two, three-way analyses of variance followed by t-tests revealed that instance type, identifiability, and variety have differential effects on generalization and discrimination. References are included. (Author)

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THE EFFECTS OF TYPE, IDENTIFIABILITY, AND VARIETY OF INSTRUCTIONAL INSTANCES ON SUBJECT MATTER CONCEPT ATTAINMENT

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The Effects of Type, Identifiability, and Variety of Instructional Instances on Subject Matter Concept Attainment

by

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Subject matter concept attainment by adult Ss was studied by experimentally manipulating instructional instances which were either positive or negative, clear or obscure, or presented in large or small variety. Training and testing instances were composed of case studies communicated via prose descriptions that had been analyzed for relevant and irrelevant attributes. Conceptualization was defined as generalization within and discrimination between classes and was assessed by having 176 undergraduate volunteers classify new positive and negative case studies after instruction from a definition and selected instances. Two, three-way ANOVs followed by t-tests revealed that instance type, identifiability, and variety have differential effects on generalization and discrimination.

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The Effects of Type, Identifiability, and Variety of Instructional Instances on Subject Matter Concept Attainment

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From basic research on concept learning have come three major variables (DeCecco, 1968) on which instructional instances may differ: (1) Instance type may be either positive if all relevant attributes are present or negative if one or more relevant attribute is missing given conjunctive concepts (Hovland, 1952), (2) Instance identifiability may range from obscure to clear depending on how embedded the relevant attributes are among the irrelevant attributes (Archer, 1966), and (3) Instance variety which may range from a few to a large number of different instances (Podell, 1958).

Studies which have investigated the influence of instance type on concept learning have found significant support for the superiority of positive over negative instances when the concepts were defined as a conjunctive combination of relevant attributes and when geometric designs were used as stimulus materials (Hovland & Weiss, 1953; Bruner, et. al., 1956; Bourne, 1968). The findings have been so convincing the Clark (1971) has been able to state that of all the possible presentation sequences, a sequence of all positive instances is most

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effective for conjunctive concepts while a sequence of negative instances is least effective. The problem encountered when trying to generalize the results of studies conducted on the instance type variable as with the instance identifiability and variety variables is that the effects on generalization and discrimination have not been studied separately. Also, most of the studies have used artificial concepts which are highly dissimilar to those taught in subject matter concept learning (Glaser, 1968).

The influence of irrelevant attributes on concept learning has also been widely investigated (e.g., Archer, . Bourne, & Brown, 1955; Bulgarella & Archer, 1962) showing that identifiability of instances varies directly with the proportion of irrelevant attributes. In the traditional experimental paradigm, of which the cited studies are examples, the focus is on original learning in contrast to subject matter acquisition where transfer of learning is the major variable of interest. Overing & Travers (1966, 1967) have demonstrated that though original learning may be somewhat less rapid, the ability to transfer concepts and rules is significantly better if the instructional instances were typical of reality, i.e., had many irrelevant attributes in proportion to relevant attributes. It remains open to question whether obscure or clear instructional instances are best for generalization and discrimination.

There is even less agreement concerning the effects of variety of instructional instances on concept learning than with the variable of instance identifiability. The early investigations of Luborsky (1945) along with more recent studies conducted

by Podell (1958), Mayzner (1962) and Dukes & Bevan (1967) lend support to the thesis that a large variety of instructional instances produces superior concept learning. In contrast, several other investigators (Adams, 1954; Shore & Sechrest, 1961; Amster & Marascuilo, 1965,) generally conclude that superior concept learning obtains when instructional instances are presented in small variety with high frequency. In none of the studies have the effects of variety of instructional instances on generalization and discrimination been investigated.

The present study was designed to investigate the effects of instance type, identifiability, and variety on generalization and of discrimination using connected discourse training materials to teach a complex conjunctive subject matter concept. More precisely, the research was designed to test the following hypotheses:

H_{Ia} : Learners who are instructed by positive instances will generalize significantly better than learners who are instructed with negative instances.

H_{Ib} : Learners who are instructed by obscure instances will generalize significantly better than learners who are instructed with clear instances.

H_{Ic} : Learners who are instructed by a large variety of instances will generalize significantly better than learners who are instructed with a small variety of instances.

H_{IIa} : Learners who are instructed by negative instances will discriminate significantly better than learners who are instructed with positive instances.

H_{IIb} : Learners who are instructed by obscure instances will discriminate significantly better than learners who are instructed with clear instances.

H_{IIc} : Learners who are instructed by a large variety of instances will discriminate significantly better than learners who are instructed with a small variety of instances.

METHOD

Design and Subjects

The experiment was conducted according to the rationale for a 2 x 2 x 2 fixed factor design. Factor A was two levels (positive and negative) of instance type, factor B was two levels (clear and obscure) of instance identifiability, and factor C was two levels (large and small) of instance variety. The independent variables were the three factors listed above, i.e., type, identifiability, and variety of instructional instances. The dependent variable was broadly defined as classifying behavior but more specifically was comprised of generalization and discrimination with regard to the concept Individualized Instruction. Generalization was tested for by having Ss classify case studies that were judged by E to be examples of the concept. Discrimination was tested for by having Ss classify case studies that were judged by E to be non-examples of the concept.

Materials

The target concept was Individualized Instruction. The instructional and testing materials were brief, two-page, case studies (Edling, 1970) of programs around the country which perported to be individualized in some manner. Each case study was classified as either a positive or negative instance of the concept Individualized Instruction and was further classified as either having clear or obscure identifiability.

The basis for determining whether a given case study was a positive or negative instance of the concept Individualized Instruction was a definition which specified four relevant attributes in conjunctive combination. For a case study to be classified as a positive instance all four relevant attributes had to be represented in one or more of the case study sentences. A case study was designated as a negative instance if one or more of the relevant attributes was missing. All sentences in each case study were analyzed for expressions of relevant attributes.

The relative identifiability of case studies stemmed from further classification based on an operational definition of identifiability. For positive instances it was assumed that clarity of identification increased as the proportion of relevant to irrelevant attributes increased while for negative instances it was assumed that clarity of identification increased as the proportion of relevant to irrelevant attributes decreased.

Through task analysis each case study was analyzed in terms of the target concept definition and the definition of identifiability resulting in the identification of four case study groups. These four groups, i.e., clear-positive, clear-negative, obscure-positive, and obscure-negative, of instructional instances made up the four stimulus pools from which instances were randomly selected to construct the instructional and testing materials. Three instances from each group were randomly selected to comprise a large variety whereas one instance from each group was selected to represent a small variety.

Procedure

For pretesting, instruction, and post-testing, 176 volunteers from the undergraduate educational psychology course at the Pennsylvania State University reported to a self-instructional learning center for two one-hour sessions. The first session included the pretest composed of four case studies and twelve multiple choice questions and the instruction consisting of a definition of the concept and illustrating instances as prescribed by the eight treatment conditions of the experimental design. The second session included a review of the instructional materials and administration of the post-test composed of eight case studies, [redacted]

[redacted]

RESULTS

Results Related to Generalization

To test the main and interactive effects of three sources of variance on generalization, a 2 X 2 X 2 analysis of variance was conducted on the number of correct case study classifications. The means and variances for each cell in the 2 X 2 X 2 data matrix are presented in Table 1.

Insert Table 1 about here

The analysis yielded a significant main effect on instance type ($F=10.42$, $1/168$, $p<.001$) and a significant three-way interaction between instance type, identifiability, and variety ($F=5.76$, $1/168$, $p<.02$). Because of the complicat-

Table 1 Cell means, standard deviations, and n's for correct category responses on the generalization test by type, identifiability, and variety of instructional instances

TYPE		IDENTIABILITY			
		Clear		Obscure	
		VARIETY		VARIETY	
		Large	Small	Large	Small
Positive	$\bar{X}$	2.32	2.05	2.09	2.18
	s	.78	.95	.92	1.22
	n	22	22	22	22
Negative	$\bar{X}$	1.32	2.23	1.68	1.64
	s	.65	.97	.72	.95
	n	22	22	22	22

ing effects of the second-order, interaction, meaningful tests of hypothesis could only be accomplished by testing for simple effects on the eight cell means. Accordingly, a series of four t-tests were computed for each of the three generalization hypotheses.

Hypothesis I (a).

To test the hypothesis that learners who are instructed by positive instances will generalize significantly better than learners who are instructed with negative instances, analysis of simple effects was conducted. The mean difference between positive and negative instances for clear identifiability and large variety was examined for statistical significance using a t-test. As hypothesized, the test revealed that positive instances ($\bar{X}$ = 2.32) produced significantly better ($t = 3.64$, $df = 168$, $p < .001$) generalization than negative instances ($\bar{X}$ = 1.32). The hypothesis was also supported ($t = 1.98$, $df = 168$, $p < .05$) by a test for significance difference between means for positive ($\bar{X}$ = 2.18) versus negative ($\bar{X}$ = 1.64) instances on obscure identifiability and small variety. However, the predicted outcome was not obtained ($t = .66$, $df = 168$, $p > .05$) when positive ($\bar{X}$ = 2.05) was compared with negative ($\bar{X}$ = 2.23) on clear identifiability and small variety nor was positive ($\bar{X}$ = 2.09) significantly superior to negative ($\bar{X}$ = 1.68) when obscure identifiability and large variety was the case ($t = 1.49$, $df = 166$, $p < .10$). That positive instances produce significantly better generalization if they are either clear and presented in large variety or obscure and presented in small variety can be seen by inspecting Figure 1.

Insert Figure 1 about here

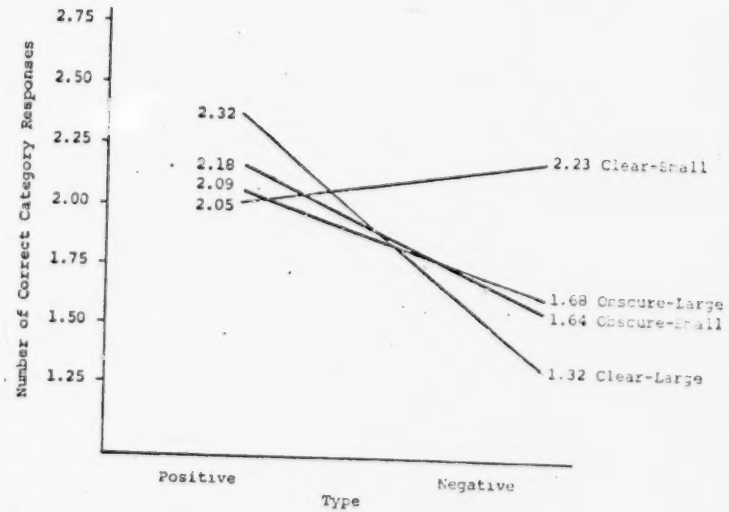

Figure 1 Plot of generalization category response cell means showing three-way, disordinal treatment interactions emphasizing instance type factor

The trend in favor of positive instances is also strong under obscure identifiability and large variety but not significantly so. The only radical departure from expectation obtained when instructional instances were presented in small variety and their identifiability was clear. Here, negative instances produced superior generalization but without statistical support. Reasonably firm support was found for the hypothesis that positive instances produce better generalization than negative instances with noted qualifications.

Hypothesis I (b).

To test the hypothesis that learners who are instructed with obscure instances will generalize significantly better than learners who are instructed with clear instances, an analysis of simple effects on cell means was conducted. The mean difference between clear and obscure instances over the four instance type and variety combinations were tested by running four t-tests. The only significant difference between clear and obscure identifiability ($t = 2.15$, $df = 168$, $p < .05$) was in favor of clear instances, contrary to expectation ($\bar{X}_C = 2.23$, $\bar{X}_O = 1.64$), under conditions of a small variety of negative instances. Obscure instances did produce superior generalization ($\bar{X}_O = 1.68$, $\bar{X}_C = 1.32$) when negative instances were presented in large variety but nonsignificantly ($t = 1.31$, $df = 168$, $p < .10$). Though the trend was very weak, obscure instances were also better than clear instances under the conditions of positivity and small variety ($\bar{X}_O = 2.18$, $\bar{X}_C = 2.05$; $t = .47$, $df = 168$, $p > .05$). In agreement with the first test mentioned, clear was superior over obscure ($\bar{X}_C = 2.32$, $\bar{X}_O = 2.09$) in a moderate but still nonsignificant trend ($t = .84$, $df = 168$, $p > .05$) when the

instructional instances were positive and presented in large variety. Inspection of Figure 2 reveals that the hypothesis regarding the superiority of obscure instances is supported, however, nonsignificantly, by two of the trends but not supported by two other trends one of which was statistically significant.

Insert Figure 2 about here

Such results make any powerful generalization impossible concerning the effects of identifiability on generalization. It is notable that identifiability seems to have little differential effects when positive instances are presented in either large or small variety (see Figure 2) but a good deal of differential effect when negative instances are presented in large or small variety especially under the clear condition.

Hypothesis I (c).

To test the hypothesis that learners who are instructed with a large variety of instances will generalize significantly better than learners who are trained with a small variety of instances, an analysis of simple effects on the eight cell means was conducted. The mean differences between large and small variety of instances over the four instance type and identifiability combinations were tested by running four t-tests. Contrary to expectation, small variety ($\bar{X} = 2.23$) resulted in superior generalization ($t = 3.32$, $df = 168$, $p < .001$) when clear negative instances were presented than large variety ($\bar{X} = 1.32$) for the only statistically significant difference of this series of tests. The only instance where large variety did produce better generalization to any clear degree than small

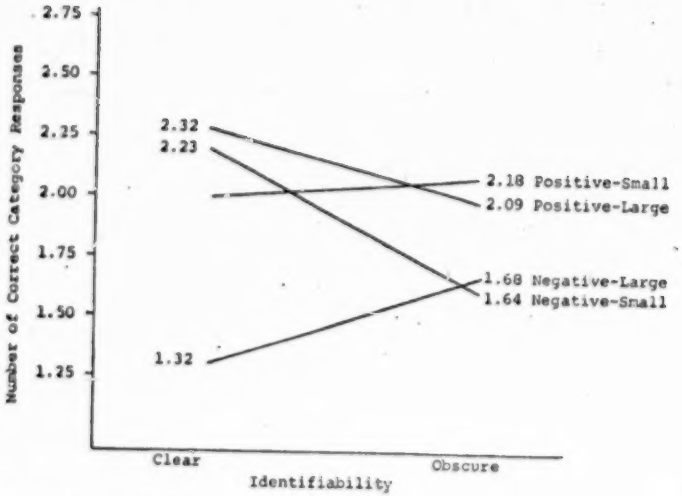

Figure 2 Plot of generalization category response cell means showing three-way disordinal treatment interactions emphasizing instance identifiability factor

variety ($\bar{X}_L$ = 2.32, $\bar{X}_S$ = 2.05) was when clear positive instances were presented. This difference, however, was insufficient to reach significance ($t = .98$, $df = 168$, $p > .05$). Hardly any recognizable difference obtained between large and small variety when instances are positive and obscure ($\bar{X}_L$ = 2.09, $\bar{X}_S$ = 2.18; $t = .33$, $df = 168$, $p > .05$) or when instances are negative and obscure ($\bar{X}_L$ = 1.68, $\bar{X}_S$ = 1.64; $t = .15$, $df = 168$, $p > .05$). It appears that under the conditions of this experiment large variety does not necessarily facilitate greater generalization than small variety contrary to prediction. The only supported conclusion that can be drawn is that small variety is superior given the conditions of clear, negative instructional instances. (see Figure 3).

Insert Figure 3 about here

Results Related to Discrimination

The data from the discrimination task consisted of the number of correct classifications of negative instances of the concept Individualized Instruction. These data were analyzed using the same rationale and procedure as those for generalization.

The means, standard deviations, and number of Ss for each cell in the 2 x 2 x 2 data matrix are presented in Table 2. Examination of the analysis revealed two significant interactions: one between instance type and instance variety ($F = 6.15$, $1/168$, $p < .05$) and another between instance identifiability

Table 2 Cell means, standard deviations, and n's for correct category responses on the discrimination test by type, identifiability, and variety of instructional instances

TYPE		IDENTIFIABILITY			
		Clear		Obscure	
		VARIETY		VARIETY	
		Large	Small	Large	Small
Positive	$\bar{X}$	2.46	3.00	2.73	2.59
	s	.96	.62	.88	1.01
	n	22	22	22	22
Negative	$\bar{X}$	2.86	2.64	3.41	2.73
	s	.99	.79	.73	.99
	n	22	22	22	22

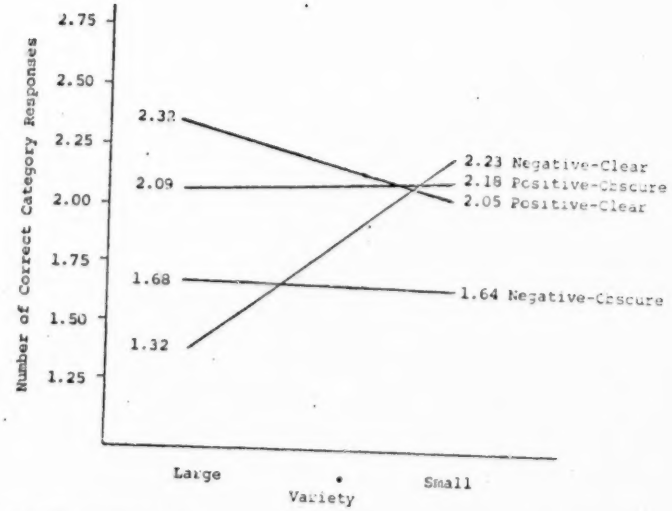

Figure 3 Plot of generalization category response cell means showing three-way disordinal treatment interactions emphasizing instance variety factor

and instance variety ($F = 4.57$, 1/168, $p < .05$). The first interaction resulted from the differential effect of instance variety on discrimination for positive or negative instructional instances. The second interaction is a result of the differential effect of instance identifiability on discrimination for clear or obscure instructional instances.

Hypothesis II (a)

To test the hypothesis that learners who are instructed by negative instances will exhibit significantly more discrimination than learners who are instructed with positive instances, an analysis of simple effects was conducted. Column means will be compared for this analysis whereas cell means were compared to test Hypothesis I (a). The difference in procedure results from significant two-way interactions in the present case while a significant three-way interaction had to be handled in the former case. The difference between positive ($\bar{X} = 2.59$) and negative ($\bar{X} = 3.14$) instances for large variety is significant ($t = 2.93$, $df = 168$, $p < .05$) and supports the hypothesis with negative instances providing for superior discrimination. However, for small variety, positive ($\bar{X} = 2.80$) was better than negative ($\bar{X} = 2.68$) but not significantly so ($t = .64$, $df = 168$, $p > .05$). The hypothesis was not supported in this latter case though there is a strong suggestion from the first significant t-test and which can be graphically observed in Figure 4 that negative instances are more facilitating at least for the large variety.

Insert Figure 4 about here

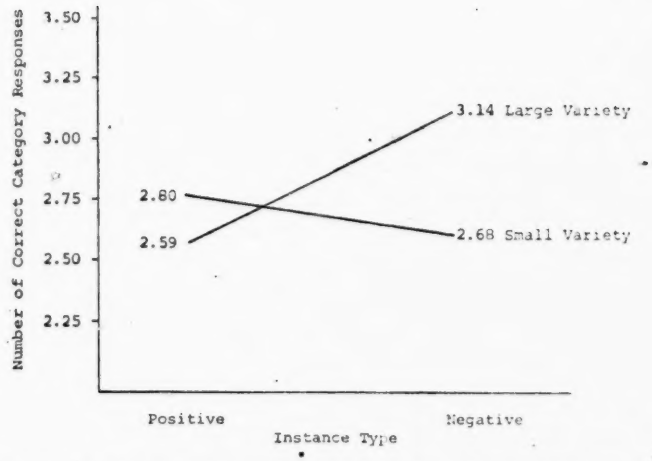

Figure 4 Plot of discrimination category response column means showing a two-way, disordinal treatment interaction emphasizing instance type factor

Hypothesis II (b)

To test the hypothesis that learners who are instructed with obscure instances will exhibit significantly more discrimination than learners who are instructed with clear instances, simple effects were analyzed. Because of the three-way interaction, Hypothesis I (b) was tested by comparing cell means. In the present case only two-way interactions are significant so column means will be compared. The hypothesis was supported when the difference between obscure ($\bar{X}$ = 3.06) and clear ($\bar{X}$ = 2.66) was tested over large variety ($t = 2.13$, $df = 168$, $p < .05$) but was not when the difference between obscure ($\bar{X}$ = 2.66) and clear ($\bar{X}$ = 2.82) was tested on small variety ($t = .75$, $df = 168$, $p > .05$). Contrary to expectation, waht trend did appear in this second comparison was in favor of clear instances. In accordance with the hypothesis that learners exposed to obscure instances will discriminate better than those exposed to clear instances and as can be seen in Figure 5, this result did obtain when a large variety of instances was presented. No statistically significant differences were detected when a small variety of instances was presented.

Insert Figure 5 about here

Hypothesis II (c)

To test the hypothesis that learners who are instructed by a large variety of instances discriminate significantly better than learners who are instructed with a small variety of instances, additional simple effects were analyzed with t-tests. Again, the column means were compared in contrast to comparison

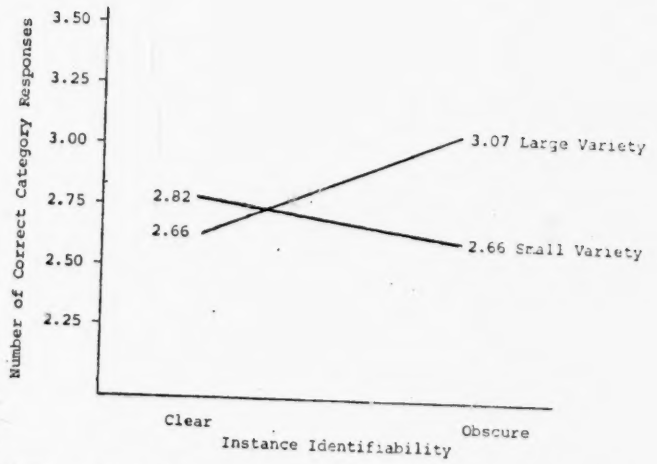

Figure 5 Plot of discrimination category response cell means showing a two-way, disordinal treatment interaction emphasizing instance identifiability factor

of cell mean as was done for Hypothesis I (c). The second order interaction in the generalization hypotheses necessitated the application of t-tests to cell means whereas the first-order interaction in the present discrimination analysis requires collapsing over columns for meaningful comparisons. When the means for large variety versus small variety for obscure identifiability were compared via a t-test, large variety ($\bar{X}$ = 3.07) was, according to expectation, significantly greater (t = 2.18, df = 168, $p < .05$) than small variety ($\bar{X}$ = 2.66). The t-test comparing large ($\bar{X}$ = 2.66) and small ($\bar{X}$ = 2.82) variety for clear identifiability did not, however, reveal a significant difference (t = .85, df = 168, $p > .05$). This particular trend, though, nonsignificant, was contrary to expectation. Additional post hoc comparisons of simple effects were computed which compared large and small variety on the instance type factor. For negative instances the advantage of large variety ($\bar{X}$ = 3.14) over small variety ($\bar{X}$ = 2.68) was supported (t = 2.45, df = 168, $p < .05$) as hypothesized. For positive instance type the trend was in the opposite direction ($\bar{X}_L$ = 2.59, $\bar{X}_S$ = 2.80) but the difference was not significant (t = 1.12, df = 168, $p > .05$). Contrary to what was found for generalization, it appears from the present data and analysis that large variety does produce superior discrimination when identifiability is obscure (see Figure 6) or when instances are negative (see Figure 7). It is of interest to note that though neither of

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Insert Figures 6 & 7 about here

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them reached significance, two of the four comparisons did show a trend for

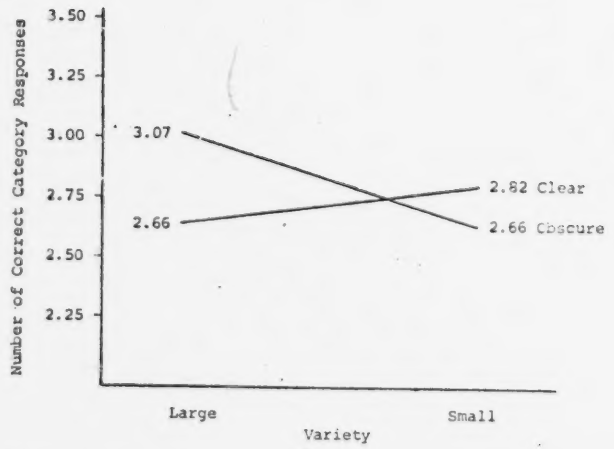

Figure 6 Plot of discrimination category response column means showing a two-way, disordinal treatment interaction emphasizing instance variety factor

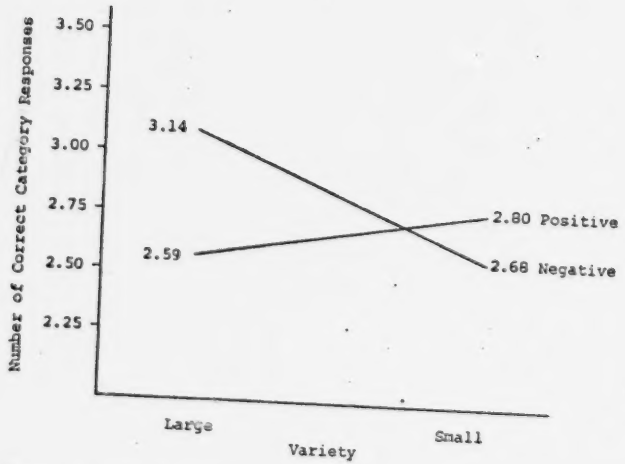

Figure 7 Plot of discrimination category response column means showing a two-way, disordinal treatment interaction emphasizing instance variety factor

small variety of instances to be superior; that is, when instances were clear or positive small variety seemed to be best. The common attributes of clarity and positivity seem to combine with small variety to produce better discrimination than large variety. However, with generalization the attributes of clarity and negativity seem to combine with small variety to be more facilitative than large variety. In the latter case statistical support was found whereas in the former case only strong trends were observed.

DISCUSSION

Instance Type

The findings of this study substantiate Markle and Tiemann's (1969, 1970) supposition that the appropriate kind of instructional instances to promote generalization are positive instances and to promote discrimination are negative instances. Unfortunately, these authors avoid any psychological explanation as to why these predicted functional relationships might exist. However, it does appear that an explanation which would coincide with their reasoning could stem from a discussion of the abstraction process. Briefly, if generalization is based on the learner's abstraction of what the concept is and is not and these abstractions are formed from the learner analyzing the attributes in search of those which are relevant and irrelevant, it would follow that instances that carry the information most directly would be superior for both processes. As demonstrated in this investigation, positive instances did appear to carry the critical information best for generalization while negative

instances carried it best for discrimination.

Though Bruner, et. al. (1956) made no distinction between generalization and discrimination in concept learning, the above rationale seems to substantially agree with their theorizing about patterns of decision making. These investigators observed, after studying Ss' concept learning strategies, that they much preferred making "direct" tests of their hypotheses concerning what the concept was. Positive instances for generalization and negative instances for discrimination would appear to make direct testing possible.

Instance Identifiability

In the present study, positive instances which had many irrelevant attributes as compared to relevant attributes or negative instances that had many relevant attributes as compared to irrelevant attributes were thought to be analogous to the "realistic" or more complex training situation in the Overing and Travers (1966, 1967) studies. These hard-to-identify or obscure instances were expected to facilitate both superior generalization and discrimination since they would force the learner to make fine generalizations and discriminations in the boundary area of his concept. The findings of this investigation did not completely support this line of reasoning. When discrimination was being tested for, obscure instances did indeed produce superior results over clear instances if they were presented in large variety. But when generalization was being tested for, clear instances proved to furnish more assistance than obscure instances if the instances were negative and presented in small variety.

The result for discrimination is in harmony with Markle and Tiemann's (1970) prescription that each nonexample should lack only one of the relevant attributes, i.e., negative instances should be difficult to tell from positive instances if fine discriminations were to be learned. It appears that both the results for discrimination and generalization observed in this investigation may be explicated in terms of performance set (Reese, 1964). Because generalization is based primarily on an abstraction of what the concept is, and since this abstraction can become quite stable as the definition specifies relevant attributes that remain constant over all positive instances, a performance set for matching abstraction with test instance would seem most effective. On the other hand, discrimination is a process based primarily on an abstraction of what the concept is not. Because the irrelevant attributes may and do vary over instances, the abstraction of what the concept is not can never become as stable and well defined as the abstraction of what the concept is. Accordingly, a great deal more searching and analyzing would seem to have to accompany the discrimination process. Therefore, it appears that a performance set for analysis would be most effective in the case of discrimination. Obscure training instances with their added complexity would tend to produce an analysis performance set whereas clear instances would tend to produce a matching performance set. As the results of this study revealed, clear instances during instruction should facilitate superior generalization because of the performance set for matching they would foster while obscure instances during instruction should facilitate superior discrimination because of the per-

formance set for analyzing they would stimulate.

Instance Variety

The author along with others (Bruner, et. al., 1956; Carroll, 1964; DeCecco, 1968; Gagne, 1970) reasoned that a variety of instructional instances was needed for adequate concept formation to take place.

Somewhat surprisingly, the results of this study revealed that a large variety of instructional instances was not necessarily the best for both of these learning outcomes. When generalization was the intended outcome, a small variety of instances produced more correct classifications if the instances were also clearly negative. In contrast, when discrimination was the intended outcome, a large variety of instructional instances resulted in a greater number of correct categorizations both when instances were obscure and when they were negative.

In contrast to the bulk of related studies, Amster and Marascuilo (1965) found evidence which corroborates the present findings with regard to the superiority of small variety for generalization. These authors found no significant differences in mean number of correct responses to intersection and union problems during training between the large and small variety conditions. However, when fourth-grade children were asked to generalize their learning to new intersection and union problems, the mean number of correct responses for the large and small variety conditions was significantly different in favor of small variety. No explanation was proposed by Amster and Marascuilo for these unexpected results except to infer that some sort of interference might have been

operating in the large variety condition and to point out that Podell (1963 a, b) also found some evidence for the advantage of a small variety over a large variety.

IMPLICATIONS FOR INSTRUCTION

Based on the conclusions arrived at in this study the recommendation is made that, when the educational goal specifies an intention for the students to acquire subject matter concepts, teachers and instructional designers should specify their instructional objectives in terms of generalization and discrimination. Objectives dealing with generalization should communicate to the student the need for recognizing new examples of the concept when they are presented. In the case of objectives that deal with discrimination, students should understand from them that they will be expected to recognize new nonexamples of the concept. Additionally, when test items are constructed for assessing the degree of concept acquisition they must be comprised of examples and nonexamples of the concepts being tested for to which the students can make generalization and discrimination responses. If both types of items are not included the complete test of concept learning will not have been attained.

A second recommendation is that when the teacher or instructional designer constructs the instructional materials, different considerations be given for facilitating generalization than those given for facilitating discrimination. It is recommended, as a general rule, that instructional instances that contain

all of the relevant attributes as specified by the definition be given to enhance the likelihood of acquiring the capacity to generalize. As a general rule, it is also recommended that instructional instances which lack one or more of the relevant attributes be given to facilitate discrimination. With somewhat less confidence, it is suggested that easy-to-identify instructional instances will be better for generalization while hard-to-identify instances will influence superior discrimination. Also with caution, it is advised that a small number of instances be presented for generalization and a large number of different instances be given to promote discrimination.

Probably the area of most direct applicability of these conclusions is that of remediation when there is insufficient subject matter concept learning. If the teacher or instructional designer know that a student is failing to acquire a concept, they are urged to attempt to discover whether his problem stems from a failure to generalize or discriminate. The learner's failure to correctly classify examples of a concept would indicate a lack of generalization while failure to correctly classify nonexamples of a concept would indicate a lack of discrimination. The appropriate remediation would follow the general conclusions of this study; that is, if the student's weakness was generalization, then positive instances should be presented, and if the student's weakness is discrimination, then negative instances should be presented. It may be that there are particular kinds of overgeneralization (insufficient discrimination) or undergeneralization (insufficient generalization) which consideration of identifiability and number of instructional instances during remediation can help. However,

additional research is needed to determine exactly what these recommendations would be.

An additional implication for effective instructional management concerns the analysis of instructional materials to be used in effecting concept learning. Without regard to the findings of this study and others, a teacher or instructional designer may have his own, well-founded reasons for believing that instructional instances which are clear or obscure or both, in a particular sequence, are best for teaching a given concept. If this is the state of affairs then the instructor needs some criteria for deciding which instances are simple and which are complex. One criteria that could be used, as demonstrated in this study, is that of relative proportions of relevant and irrelevant attributes. To use these criteria would require that the instructional designer know what the relevant and irrelevant attributes are and then to make some sort of frequency count of how many are present in the various instances. Once this was done, the instances could be rank ordered, as was done for this study, and then sequenced or presented as the teacher deemed most appropriate. This same process is also recommended for distinguishing between positive and negative instances when the concept is conjunctive and the instructional instances are very complex.

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